CLASSIFICATION, TERMINOLOGY AND MEASUREMENTS IN SPONDYLOLISTHESIS+

Leon L. Wiltse, M.D.*

Classification

Spondylolisthesis is a slipping of all or part of one vertebra forward on the other. The term is derived from the Greek "spondylo" meaning vertebra and "olisthesis" meaning to slip or slide down an incline.

When the two words are combined as in spondylolisthesis, as is customary when combining words in the Greek, the last vowel of the first word is dropped. So the word becomes spondylolisthesis.

The following classification[12] of spondylolisthesis has been derived from previous classifications published by the author, by Newman, and also by MacNab.[6,7,8]

I. Dysplastic (congenital)
II. Isthmic
  A. Lytic–fatigue fracture of the pars.
  B. Elongated but intact pars.
  C. Acute fracture of pars (not to be confused with "traumatic" [see IV]).
III. Degenerative
IV. Post Traumatic
V. Pathologic

Discussion of the types

Dysplastic: (Fig. 1)

There is congenital dysplasia of the upper sacrum or the neural arch of L5. Because of this dysplasia, there is insufficient strength to withstand the forward thrust of the superincumbent body weight, and the last free lumbar vertebra gradually slips forward. The pars interarticularis may remain unchanged. If it remains unchanged and the ring is intact, the slip cannot exceed more than about 35 percent before there will be pressure on the cauda equina. There is a strong hereditary element in this type.[14]

Isthmic

The basic lesion is in the pars interarticularis. Secondary changes (e.g., alteration in the shape of the body of L5) may occur but are not fundamental to its etiology.

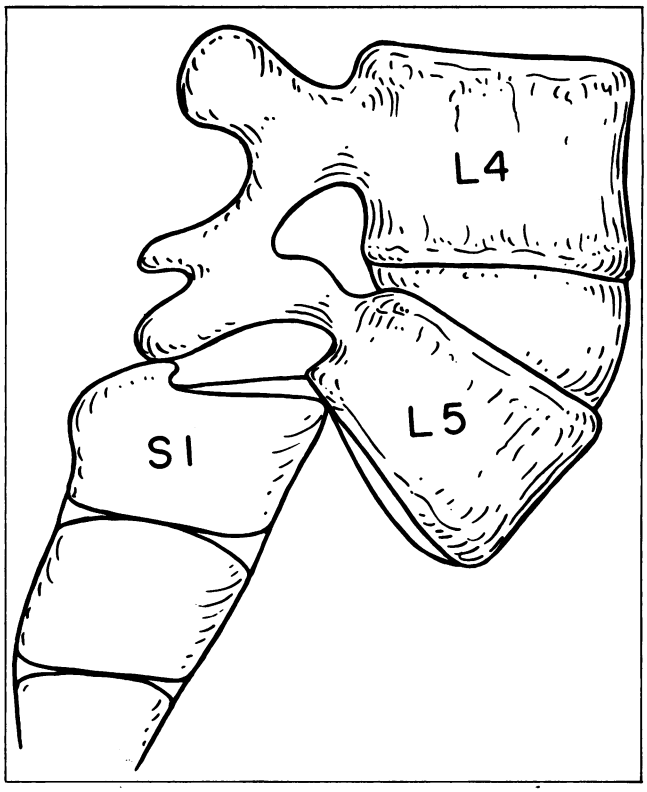

Figure 1. Drawing of congenital or dysplastic spondylolisthesis. Note superior articular processes of S1 are underdeveloped.

Subtype A, Lytic (Fig. 2)

This is due to separation of the pars resulting from a fatigue fracture.[11] It is the common type below age 50. Statistically, it is seldom seen in patients below age 5, but it does occur even in infancy. At the end of the first year of school, the incidence is 4.4 percent. By the age of 18, the incidence increases to 6 percent.[1] Boys have the condition about twice as frequently as girls. Flexion, extension and twisting motions are all probably important in producing the stress fractures, but extension is most important.[4,14]

Subtype B, Elongation of the pars without separation (Fig. 3)

This is fundamentally the same disease as Subtype A. Repeated micro-fractures in the pars allow it to heal in an elongated position as the body of L5 slides forward. The author knows of five families in which the pro-

* 2840 Long Beach Blvd., Long Beach, California 90806

+ Presented as the first Camp Lecture 1980-1981 University of Iowa Hospitals and Clinics, Iowa City, Iowa 52242

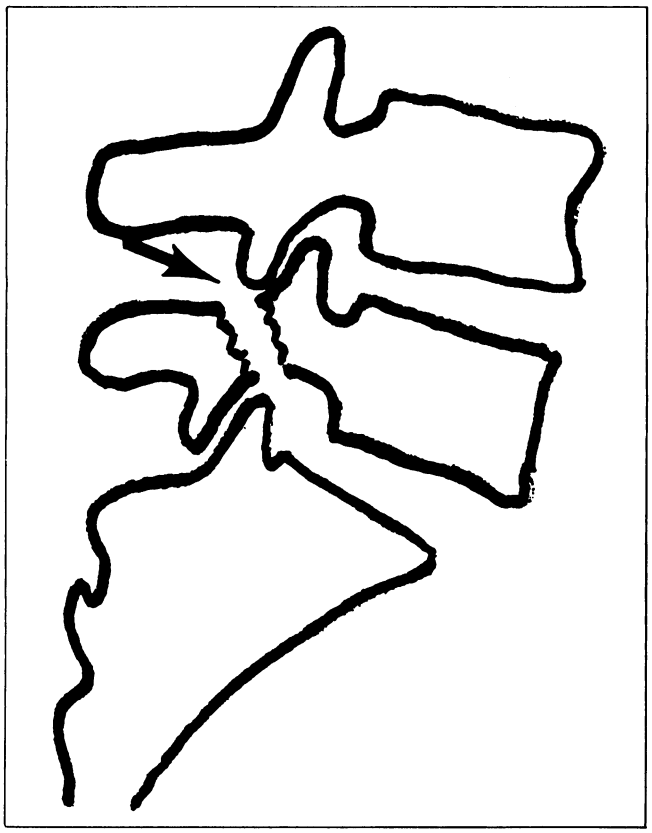

Figure 2. Lateral drawing of isthmic spondylolisthesis, Type II-a.

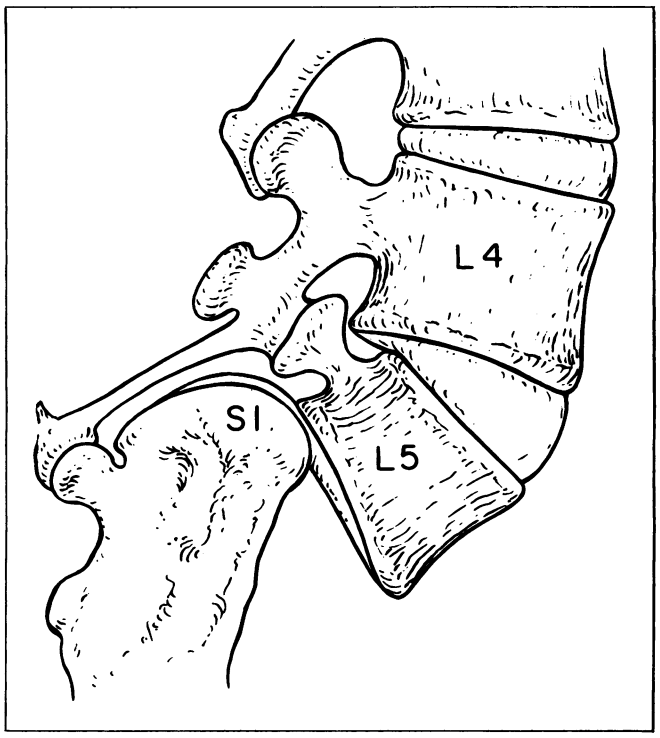

Figure 3. Lateral drawing of elongated but intact pars, Type II-b.

bands had an elongated but intact pars while several other members of their immediate families had typical spondylolysis or spondylolisthesis with the classic pars defect seen in Subtype A.

Subtype C, Acute pars fractures

These are an acute fracture of the pars secondary to severe trauma and are extremely rare.

Degenerative (Fig. 4a and b)

This lesion is due to longstanding intersegmental instability. Remodeling of the articular processes at the level of involvement results. Farfan[3] believes that in addition to degeneration of the disc there are multiple small stress compression fractures of the inferior articular processes of the olisthetic vertebra. As the slip progresses, the articular processes change directions and become more horizontal. One side nearly always rotates more than the other. This is an integral characteristic of this disease. Farfan believes that the typical hour-glass deformity seen on the myelogram is due to rotation of the upper vertebra with displacement of the pedicle.

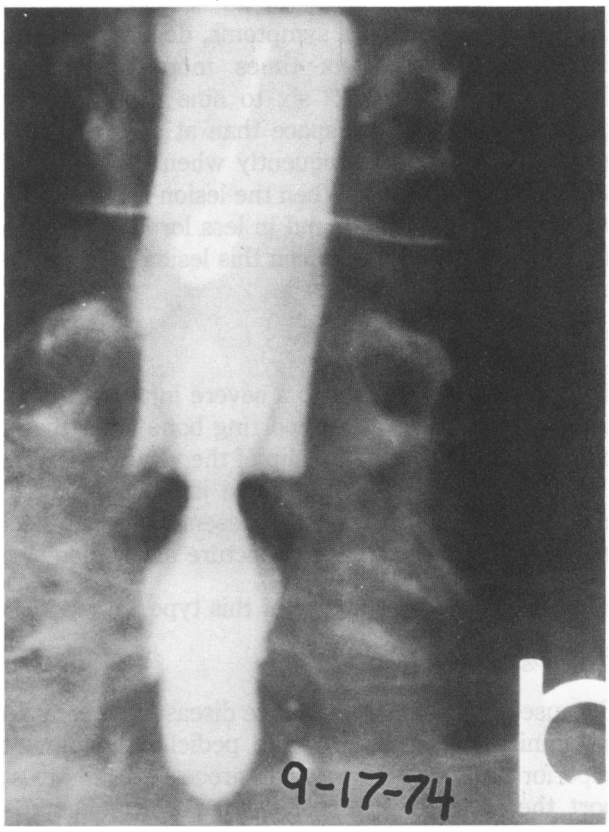

Figure 4a. AP myelogram of a typical case of degenerative spondylo.

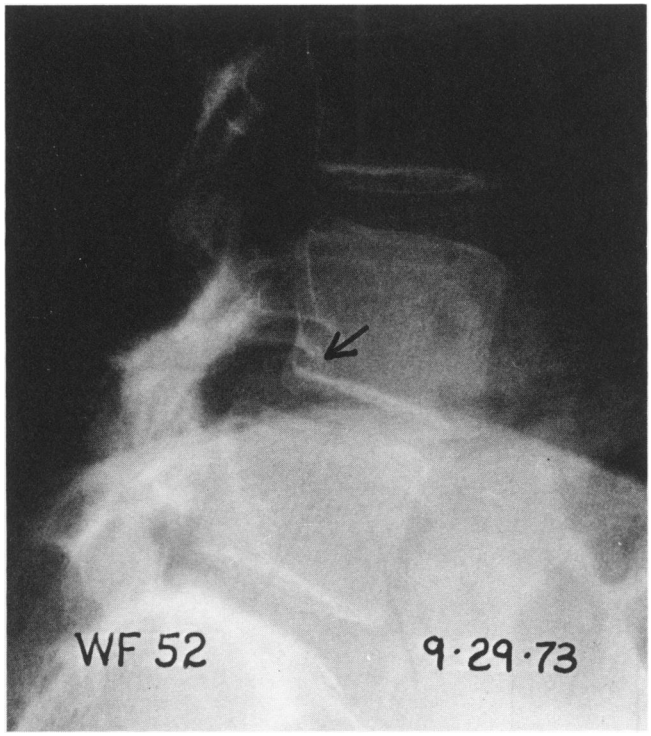

Figure 4b. Lateral myelogram of a case of degenerative spondylolisthesis.

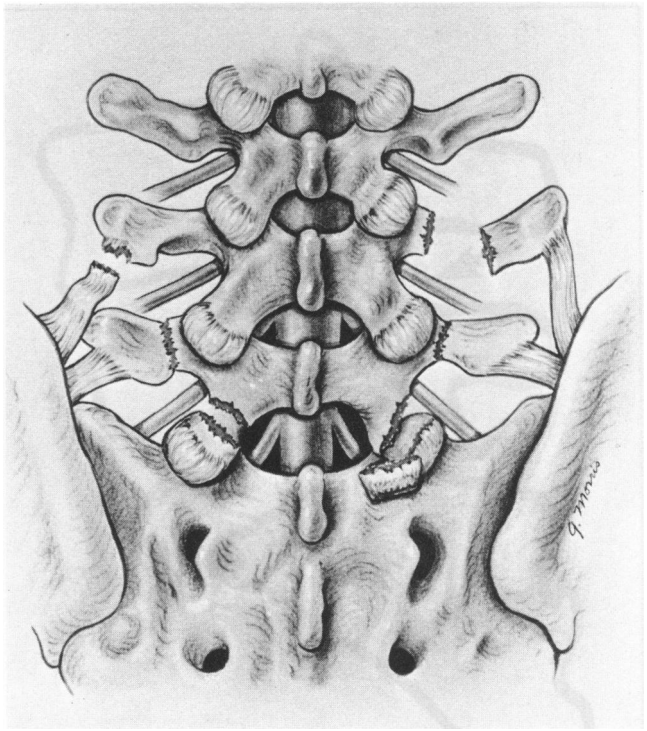

Figure 5. Drawing of an actual case of traumatic spondylolisthesis.

In patients with clinical symptoms, degenerative spondylolisthesis occurs six times more frequently in females than in males;[9] six to nine times more frequently at the L4 interspace than at adjoining levels; and four times more frequently when the 5th lumbar vertebra is sacralized. When the lesion is at L4, the L5 vertebra is more stable and in less lordosis than average. The author has not seen this lesion in any patient under age 40.

Post Traumatic (Fig. 5)

This lesion is secondary to a severe injury which fractures some part of the supporting bone other than the pars. This allows forward slip of the vertebra above on the one below. Unlike the acute isthmic fracture, an isolated pars fracture is not present. The slip occurs gradually. It is not an acute fracture dislocation.

I see about one case a year of this type.

Pathologic

Because of local or general bone disease, the bony hook mechanism (consisting of the pedicle, the pars, the superior and inferior articular processes) fails to support the forward thrust of the superincumbent body weight and forward slip of a vertebra on the one below occurs.

Terminology and Measurements

Dr. Robert Winter and Dr. David Bradford collaborated with me in formulating this terminology.[2,13]

A. *Displacement* (anterior translation, slip, olisthesis)

The forward displacement of one vertebra in relation to the next one below is best measured as a percentage. The anterior–posterior diameter (depth) of the body of S1 is used as the baseline. The widest point of the body of S1 is chosen. A line is drawn at right angles to a previously drawn line on the back of S1 (Fig. 6).

B. *Sacral Inclination* (sacral tilt, sacral vertically)

Sacral inclination refers to the relationship of the sacrum in the sagittal plane to its horizontal or vertical reference line. Normally the sacrum is inclined forward. That is, the upper sacrum is more anterior, the lower sacrum more posterior.

To determine sacral inclination a lateral roentgenogram is taken with the patient standing erect with the knees straight. A vertical line is drawn perpendicular to the floor and the relationship of the sacrum to this line is established.

The problem is the definition of the sacrum which tends to be a curved bone. The best reference area appears to

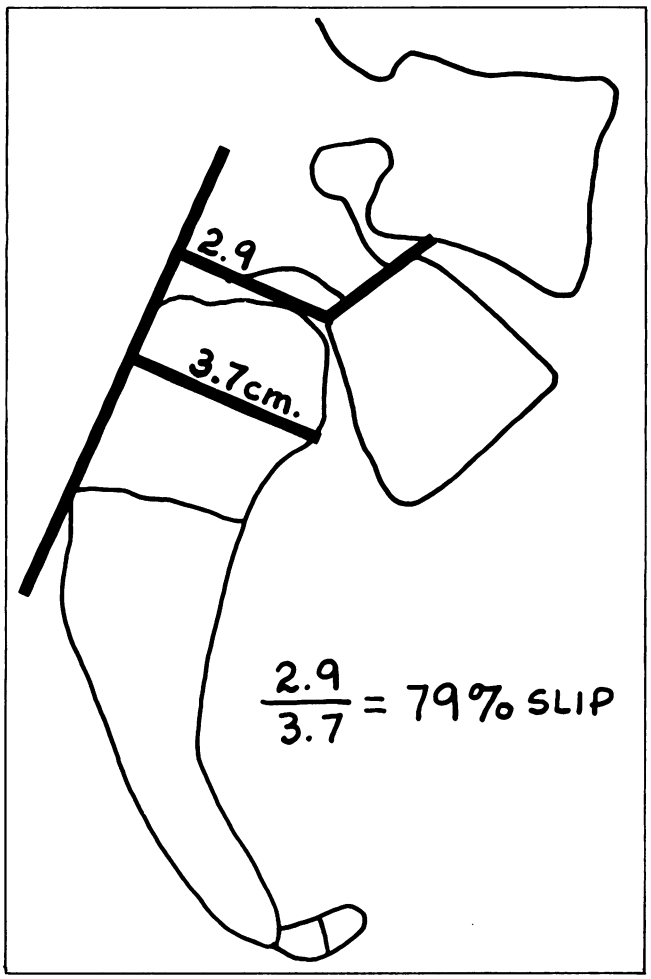

Figure 6. Anterior displacement. The quantity of anterior displacement is expressed as a percentage. The percentage of anterior displacement (slip) is obtained by dividing the amount of displacement (determined by the relationship of the posterior cortex of L5 to the posterior cortex of S1) by the maximal anteroposterior diameter of S1 and multiplying by 100. There can be no higher quantity of slip than 100%.

be the posterior aspect of S1 which is usually a straight line and can be used as a reproducible line of reference. This same line is used also for other measurements. Occasionally, this line cannot be drawn accurately. Then, a dot can be made at the center of the top of S1 and another dot in the center of the top of S2 and a line drawn between the two dots can serve as a reference line.

As the sacrum tends to become more vertical with increasing olisthesis, the angle of inclination will become smaller (Fig. 7).

C. *Sagittal Rotation* (slip, sagittal roll, lumbosacral kyphosis) (Fig. 8)

Sagittal rotation refers to the angular relationship between L5 and S1 in an L5, S1 olisthesis. The line along the posterior aspect of S1 is one again used as a line of reference for the sacrum. A line drawn along the anterior aspect of L5 almost always parallels the posterior aspect of L5 and is perpendicular to the line along the upper end plate of L5. This line will intersect the S1 line, giving an angular relationship to S1.

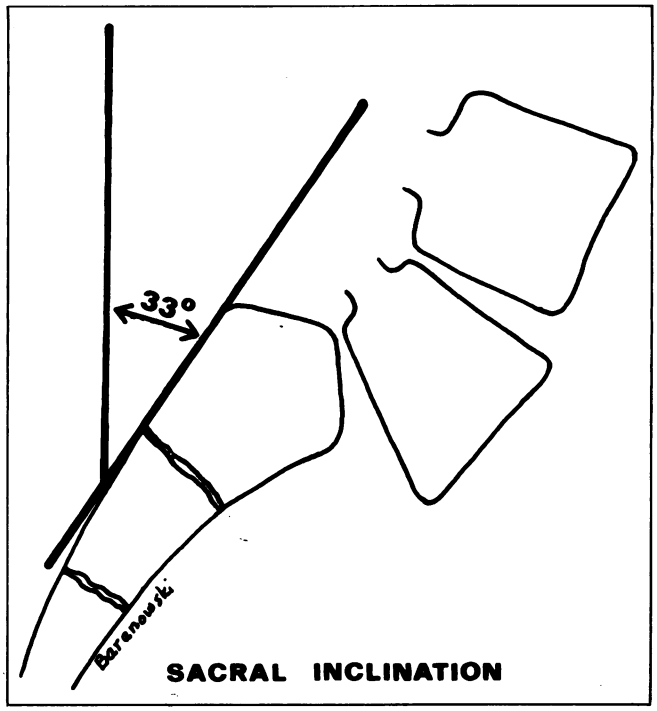

Figure 7. Sacral inclination. Sacral inclination is determined by drawing a line along the posterior cortex of S1 and measuring the angle created by this line intersecting the true vertical line.

The greater the degree of sagittal rotation, the higher the angle. Occasionally this angle is less than zero and should be recorded as a minus figure.

D. *Lumbar Lordosis* (Swayback) (Fig. 9)

Lumbar lordosis is the quantity of anterior curvature of the lumbar spine in the sagittal plane. In patients without spondylolisthesis it is traditional to measure the angle between the upper end plate of L1 and the upper end plate of S1. However, in spondylolisthesis there tends to be an abnormal kyphotic relationship between L5 and S1. The lumbar lordosis is a secondary or compensatory malalignment rather than a part of the primary deformity. Therefore, it is appropriate to measure lumbar lordosis from the top of L1 to the top of L5 and not L1 to S1.

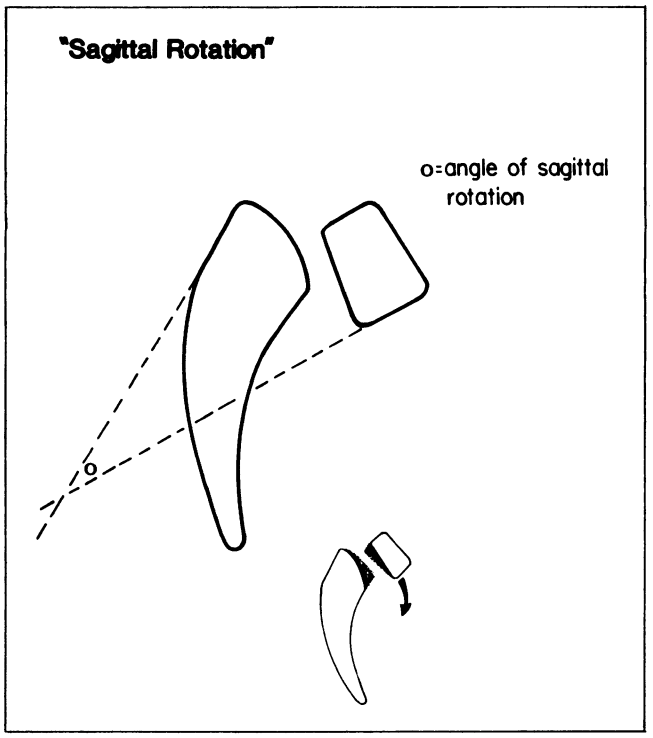

Figure 8. Sagittal rotation. Sagittal rotation is the term used to express the angular relationship between L5 and S1. It has previously been called "sagittal roll," "slip angle," or "lumbosacral kyphosis." The angular value (angle 0) is determined by extending a line from along the posterior cortex of L5 until it intersects the reference line drawn along the posterior cortex of S1. In the normal individual, this angle is usually zero. The greater the degree of sagittal rotation, the higher the angular value.

E. *Wedging of the olisthetic vertebra (lumbar index)* (Fig. 10)

A less frequently used measurement, the wedging of the olisthetic vertebra is most appropriately expressed as a percent wedging, obtained by dividing the anterior vertebral height into the shortened posterior vertebral height and multiplying by 100. Percentage of wedging seems a more universally understandable concept than an "index" or "ratio."

F. *Sacral lumbosacral angle* (angle of the cephalic vertebral end plate of S1 with the horizontal, lumbosacral angle; lumbar lordosis[5]).

The angle of the cephalic border of the body of S1 often differs from the angle of inclination of the sacrum (Fig. 11).

Ferguson, Von Lachum and others[10] use the term "lumbosacral angle" for this. However, this seems incorrect since this is actually the angle of the cephalic border of the first sacral centrum with the horizontal and not the

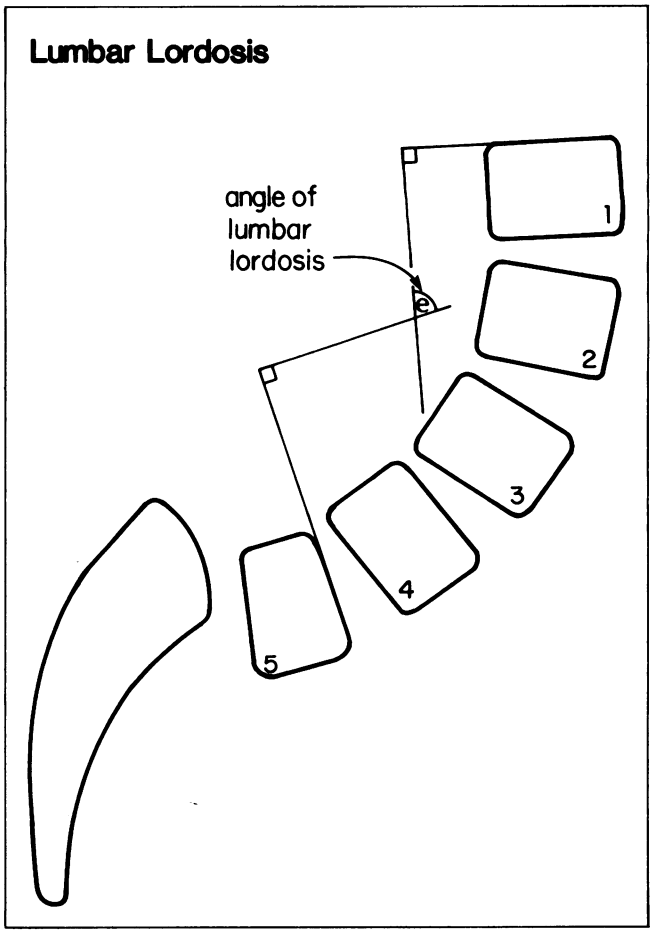

Figure 9. Lumbar lordosis. In patients with spondylolisthesis, the quantity of lumbar lordosis is defined as angle e, the angle created by perpendicular lines from the superior end plates of L1 and L5. With significant degrees of sagittal rotation, there may be lordosis extending well up into the thoracic spine in which case "total spinal lordosis" can be distinguished from lumbar lordosis.

angle of S1 with the lumbar vertebra. One should calculate this angle from an x-ray with the patient in the standing position.

As noted in the line drawing (which is taken from a patient), the angle of the cephalic border of S1 may be quite different from the angle of inclination.[4] Farfan calls this the sacral lumbosacral angle. The final name of this is yet to be settled upon.

One might wonder why this is important. It is important because there may be a relationship between this angle and symptoms. Nachemson has reported that, according to the Swedish statistics, the incidence of symptoms increases if this angle is greater than 70 degrees. This has frequently been called lumbar lordosis but this too is obviously an incorrect term for this measurement.

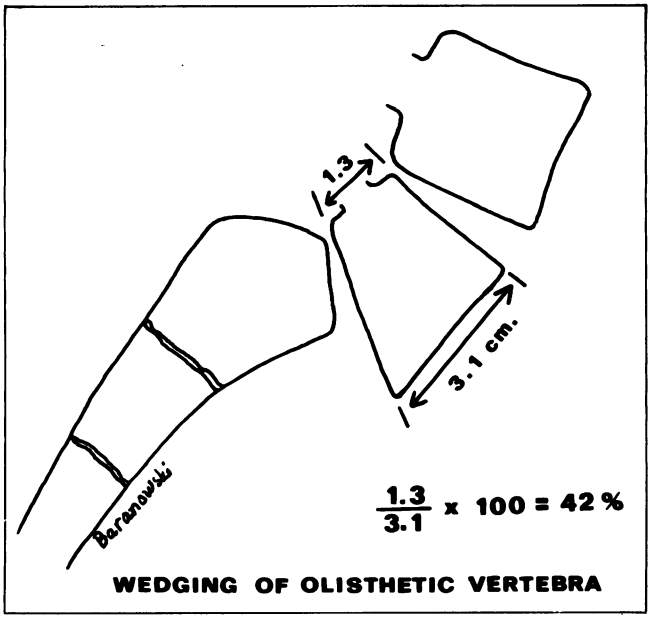

Figure 10. Wedging of the olisthetic vertebra. Wedging of the olisthetic vertebra (usually L5) is expressed as a percentage, determined by dividing the posterior height of L5 by the anterior height of L5 and multiplying by 100.

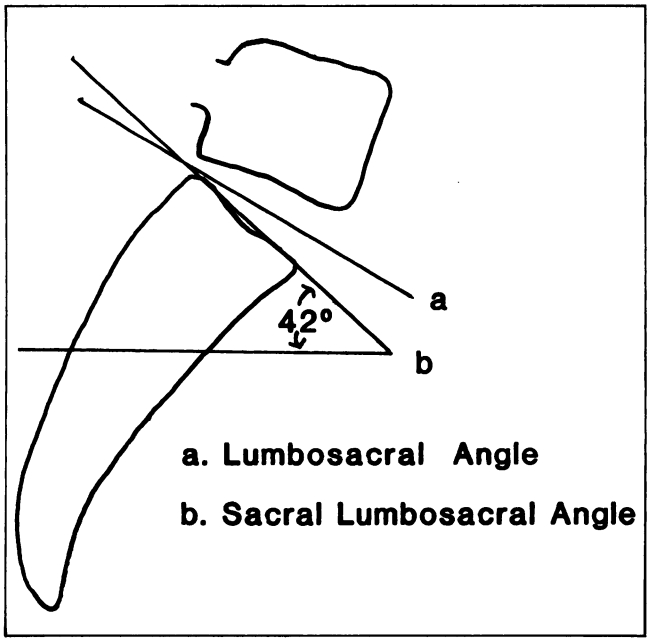

Figure 11. The lumbosacral angle should be a line bisecting the disc of L5. However, the line we are interested in is a line drawn across the cephallic border of the centrum of S1. Farfan calls this the "sacral lumbosacral angle."

Summary

The use of standardized nomenclature can greatly facilitate international communication and improve the quality of scientific presentations in the field of spondylolisthesis.

A system of terminology and measurement is being developed by a cooperative effort between members of the International Society for the Study of the Lumbar Spine and Scoliosis Research Society. Ultimately this will be published and I hope will stand unchallenged at least for a few years.

Bibliography

[1]Baker, D.R.: Personal communication, 1981.

[2]Bradford, D.: Personal communication, 1981.

[3]Farfan, H.F.: Mechanical disorders of the low back. Lea & Febiger, Philadelphia, 1973.

[4]Farfan, H.F.: The radiological anatomy of degenerative spondylolisthesis. Spine 5, no. 5:412-418, 1980.

[5]Ferguson, A.: Textbook on radiology.

[6]MacNab, I.: Paper read at the meeting of the International Society for the Study of the Lumbar Spine, London, 1975.

[7]Newman, P.H.: Etiology of spondylolisthesis. J. Bone and Joint Surg., 45-B:39, 1963.

[8]Newman, P.H.: Paper read at the meeting of the International Society for the Study of the Lumbar Spine, London, 1975.

[9]Rosenberg, N.: Degenerative spondylolisthesis, predisposing factors. J. Bone and Joint Surg., 57-A:467, 1975.

[10]Von Lackum, W.H.: see Textbook on radiology by A. Ferguson.

[11]Wiltse, L.L., Widell, E.H. Jr., Jackson, D.: Fatigue fracture: the basic lesion in isthmic spondylolisthesis. J. Bone and Joint Surg., Vol. 57-A, No. 1, 17-22, 1975.

[12]Wiltse, L.L., Newman, P.H., MacNab, Ian: Classification of spondylolysis and spondylolisthesis. Clin. Ortho. Vol. 117, p. 23, June 1976.

[13]Winter, R.: Personal communication, 1981.

[14]Wynne-Davies, R., Scott, H.S.: Inheritance and spondylolisthesis: a radiographic family survey. J. Bone and Joint Surg., 61-B:301, 1979.